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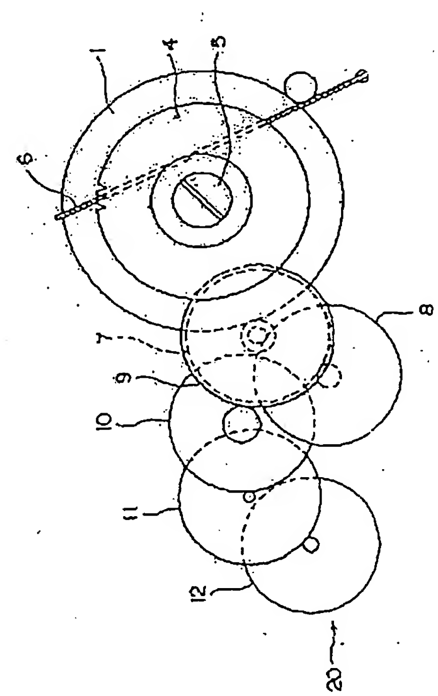
(54) **Electromagnetic transducer and electronic device including the transducer**

(57) The invention intends to provide an electromagnetic transducer which can improve conversion efficiency by reducing the weight of a rotor and thinning a rotor shaft, and which has succeeded in reduction of both size and weight. An electromagnetic transducer includes a rotor comprising a plurality of magnets with N and S poles arrayed alternately in the direction of rotation of the rotor, and a back yoke for supporting the plurality of magnets. The back yoke is formed such that an area of a section area of the back yoke sectioned by a plane passing the center of each magnet as viewed in plan and the rotor shaft is smaller than a sectional area of another portion of the back yoke depending on distribution of magnetic force lines generated inside the back yoke between the N and S poles of the adjacent magnets. With such a reduction of the sectional area of the back yoke, the weight of the back yoke and hence the overall weight of the rotor can be reduced while the magnetic force lines flowing into the magnet are prevented from being saturated.

[FIG. 1]



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Description

[0001] The present invention relates to an electromagnetic transducer which includes a rotor and a coil, and which reciprocally transduces kinetic energy generated due to rotation of the rotor and electrical energy generated in the coil.

[0002] Heretofore, an electromagnetic transducer has been utilized which transduces changes of magnetic flux due to rotation of a rotor into electrical energy with a coil, or conversely transduces electrical energy into rotary power of the rotor. As examples of utilizing such an electromagnetic transducer in a multipolar power generator, there are known multipolar power generators described in, e.g., Japanese Unexamined Patent Publication No. 8-75874, No. 9-211152, and a paper in Proceedings of The Swiss Society of Chronometry reported by Asulab S.A. on October 2, 1997.

[0003] Each of those publicized multipolar power generators comprises a plurality of magnets supported rotatably about a predetermined axis and arranged on a plane perpendicular to the predetermined axis with N and S poles arrayed alternately in the direction of rotation, a rotor having a back yoke made of soft iron and supporting the plurality of magnets, and a coil made up of windings and arranged near the rotor. In that type of multipolar power generators, when a rotor is rotated with a mechanical energy source such as a barrel main spring, the magnetic flux near the coil is changed with the rotation of the rotor, and an induced current flows through the coil windings under electromagnetic induction.

[0004] The above-described multipolar power generator is suitable as a power supply source for, e.g., a speed-governing control circuit of an electronically controlled watch or the like because inductive electromotive forces can be generated with stability by such an arrangement that the plurality of magnets are arranged with N and S poles arrayed alternately in the direction of rotation. Also, comparing with a conventional power generator which comprises a rotor, a metal-made core arranged near the rotor, and a stator including a coil wound over another portion of the core, a power generator producing no iron loss and having higher efficiency of power generation can be realized due to the absence of the core. In addition, since the metal-made core is not arranged near the rotor, a power generator having a small cogging torque and very excellent startability can be achieved.

[0005] However, the following problems are experienced in the electromagnetic transducer described above.

(1) The rotor includes the back yoke made of soft iron and the plurality of magnets arranged on the back yoke as described above, and therefore has an increased weight. Accordingly, a rotor shaft supporting those components is required to have a diameter sufficiently durable to the increased weight. An increase of diameter of the rotor shaft increases a contact area between itself and a main plate and a bearing support seat which hold the rotor shaft. Correspondingly, the rotor rotation is restricted and the power generation efficiency of the multipolar power generator is reduced.

(2) To rotate the rotor having the increased weight with stability, a bearing portion formed in the main plate, etc. requires to be constituted by an anti-vibration bearing, which has been used in conventional mechanical watches, for the purpose of improving an anti-vibration ability and an anti-impact ability. This results in an increased thickness of the multipolar power generator.

[0006] The above problems are also similarly encountered in the case of employing an electromagnetic transducer as a motor utilizing electrical energy as a power source.

[0007] An object of the present invention is to provide an electromagnetic transducer which can improve conversion efficiency by reducing the weight of a rotor and thinning a rotor shaft, and which has succeeded in reduction of both size and weight.

[0008] To achieve the above object, the present invention provides an electromagnetic transducer comprising a rotor and a coil and transducing kinetic energy generated with rotation of the rotor and electrical energy generated in the coil, wherein the rotor comprises a rotor shaft serving as the center of rotation, and a back yoke including a magnetic body with N and S poles arrayed in the direction of rotation of the rotor, the magnetic body being held in close contact with the back yoke, and the back yoke is formed such that an area of a section of the back yoke sectioned by a plane passing the center of the magnetic body as viewed in plan and the rotor shaft is smaller than a sectional area of another portion of the back yoke depending on distribution of magnetic force lines generated inside said back yoke.

[0009] Here, the term "electromagnetic transducer" represents a concept including a power generator for rotating a rotor with mechanical energy supplied from a driving mechanism such as a main spring and generating electrical energy in a coil, and a motor for applying electrical energy supplied from an electricity accumulating means so as to flow through a coil and rotating a rotor to generate mechanical energy.

[0010] Also, the magnetic body is just required to satisfy such an arrangement that N and S poles are arrayed in the direction of rotation of the rotor. For example, the magnetic body can be constructed by magnetizing a surface of an annular magnetic body into a plurality of poles, or by arranging a plurality of magnets with N and S poles arrayed alternately on the back yoke.

[0011] Further, the phrase "a section of the back yoke sectioned by a plane passing the center of the magnetic body as viewed in plan and the rotor shaft" means a sec-

tion of the back yoke in the form of a flat plate, the section containing the center of the magnetic body as viewed in plan and facing in the direction of thickness of the back yoke. The phrase "smaller than a sectional area of another portion of the back yoke depending on distribution of magnetic force lines generated inside said back yoke" means that a section of the back yoke facing in the direction of thickness thereof is reduced to such an extent that the magnetic flux is not saturated at a close contact portion between the back yoke and the magnetic body. More concretely, the area of the section can be reduced by forming a cutout in the direction of thickness of the back yoke, or by forming a recess in which the magnetic body is embedded, or by forming a hole in a portion of the back yoke inward of the magnetic body.

[0012] With the above features of the present invention, since the area of the section of the back yoke is reduced to such an extent that the magnetic flux inside the back yoke is not saturated, the weight of the back yoke can be reduced and hence the overall weight of the rotor can be reduced. Correspondingly, the rotor shaft can be thinned, and the efficiency of power generation and the driving efficiency of a motor can be improved. In addition, a reduction of the weight of the rotor contributes to simplifying and downsizing the structure of an anti-vibration bearing, thus resulting in a reduction of both size and weight of the electromagnetic transducer.

[0013] When the magnetic body is constructed by magnetizing a surface of an annular magnetic body into a plurality of poles, a multipolar rotor can be formed just by magnetizing one magnetic body, the rotor as one component of the electromagnetic transducer can be manufactured with ease.

[0014] When the magnetic body is constructed by a plurality of magnets with N and S poles arrayed alternately on the back yoke, the magnets are only required to be in the least necessary portions, and therefore the rotor can be further reduced.

[0015] The following arrangements are conceivable to realize the above feature that "a section of the back yoke sectioned by a plane passing the center of the magnetic body as viewed in plan and the rotor shaft" is smaller than another section depending on magnetic force lines.

(1) The area of the section facing in the direction of thickness of the back yoke can be reduced by forming cutouts in the back yoke to extend from an outer periphery of the back yoke toward the center of the rotation and to pass the centers of the poles of the magnetic body in one-to-one relation.

(2) The area of the section facing in the direction of thickness of the back yoke can be reduced by forming recesses in one surface of the back yoke opposed to the other surface thereof, which is held in contact with the magnetic body, in one-to-one relation to the centers of the poles of the magnetic body.

(3) When the magnetic body is constructed by a plurality of magnets with N and S poles arrayed alternately on the back yoke, the area of the section facing in the direction of thickness of the back yoke can be reduced by forming cutouts in an outer peripheral edge of the back yoke at positions depending on the arrangement of the plurality of magnets on the back yoke.

(4) When the magnetic body is constructed by a plurality of magnets with N and S poles arrayed alternately on the back yoke, the area of the section facing in the direction of thickness of the back yoke can be reduced by forming holes in the back yoke at positions depending on the arrangement of the plurality of magnets on the back yoke inward of the magnets.

(5) When the magnetic body is constructed by a plurality of magnets with N and S poles arrayed alternately on the back yoke, the area of the section facing in the direction of thickness of the back yoke can be reduced by forming a plurality of recesses in the back yoke to receive the plurality of magnets for mutual fitting in one-to-one relation.

[0016] With the arrangements (1), (2) and (5), since the density of magnetic line forces in the direction of thickness of the back yoke between the adjacent N an S poles is low in a portion just under the center of each pole of the magnetic body, the weight of the back yoke can be reduced by reducing the sectional area in the direction of thickness of the back yoke to such an extent that the magnetic flux is not saturated in the above portion. Further, even with a reduction of the sectional area, the magnetic flux inside the back yoke is not saturated and therefore the magnetic flux radiated from the magnetic body is not lessened.

[0017] With the arrangements (3) and (4), since there is a portion in the direction along surfaces of the back yoke and the magnetic body held in close contact with each other where the density of magnetic line forces is low, the weight of the back yoke can be reduced by forming in the back yoke along its contact surface with the magnetic body to such as extent that the magnetic flux is not saturated, and thereby reducing the sectional area in the direction of thickness of the back yoke. As with the above arrangements, therefore, the magnetic flux radiated from the magnetic body is not lessened.

[0018] Of the above arrangements for reducing the area of the section of the back yoke, with the arrangement (5) of forming a plurality of recesses in the back yoke to receive the magnets for mutual fitting, the weight of the back yoke is reduced due to a reduction of the sectional area, and at the same time the contact area between the magnet and the back yoke is increased. Accordingly, a path through which the magnetic force lines inside the back yoke flow is increased. Correspondingly, the magnetic flux radiated from the magnet toward the coil is increased, resulting in an electromagnetic transducer with

high power generation efficiency and high driving efficiency.

[0019] Also, with the provision of the recesses to receive the magnets for mutual fitting, movement of the magnets along the surface of the back yoke held in contact with the magnets is restricted. Therefore, the magnets can be held on the back yoke at predetermined positions with no need of bonding the magnets to the back yoke using an adhesive or the like. This increases the efficiency in manufacture of the rotor.

[0020] Preferably, the recesses are each formed such that a width of each recess in the direction perpendicular to the direction of depth thereof gradually decreases toward the bottom of the recess, and a portion of each of the magnets which is fitted into each recess is configured corresponding to the shape of the recess.

[0021] With the recesses having such a shape, the magnetic force lines flowing inside the back yoke are allowed to smoothly flow into the magnet in the direction perpendicular to the end surface portion of the magnet which is fitted into the recess. Accordingly, the magnetic force lines radiated from the magnet to the coil are further increased, resulting in an electromagnetic transducer with higher power generation efficiency and higher driving efficiency. In particular, by forming the recess to have a curved surface and forming the fitted portion of the magnetic body to have a shape corresponding to the curved surface, the direction of incidence of magnetic force lines from the back yoke to the magnetic body can be aligned with the direction normal to the surface of the magnetic body. This result is effective in increasing magnetic force lines radiated from the magnetic body.

[0022] Preferably, the depth of the recesses is set depending on a boundary between the poles of each of the magnets fitted into the recesses. More concretely, considering a cylindrical magnet having poles in its upper and lower surfaces, it is preferable that the boundary between the poles be formed substantially at the middle of a cylindrical shape, and the depth of the recesses be set slightly smaller than the height of a half of the cylindrical magnet.

[0023] If the boundary between the poles is embedded within the back yoke, the poles would be subject to twisting and the magnetic force lines inside the back yoke would not efficiently flow in the magnet. By setting the depth of the recesses as mentioned above, the magnetic force lines inside the back yoke are allowed to flow into the magnets more efficiently. As with the above feature, therefore, an electromagnetic transducer with high power generation efficiency and high driving efficiency is provided.

[0024] Preferably, the recesses and the magnets are formed to have a circular shape. By forming the recesses and the magnets to have such a shape, manufacture of the back yoke and the magnets can be facilitated.

[0025] When the rotor includes a pair of back yokes arranged in opposed relation with coils disposed therebetween, the rotor shaft preferably includes positioning means for determining relative positions of the pair of back yokes. More specifically, the relative positions of the pair of back yokes are set such that N poles of the magnetic body disposed on one of the back yokes are arranged in opposed relation, viewed in plan, to S poles of the magnetic body disposed on the other.

[0026] Stated otherwise, since the relative positions of the pair of back yokes can be precisely positioned by the positioning means, each pair of magnets disposed on the pair of back yokes can be arranged in precisely opposed relation. It is therefore possible to render magnetic force lines to penetrate the coil comprising the pair of yokes with high density, and to develop large changes of the magnetic flux in the coil.

[0027] The positioning means preferably includes a rotor shaft formed to have a polygonal shape in a radial section, and polygonal holes formed in the pair of back yokes to receive the rotor shaft for mutual fitting.

[0028] In other words, just by forming the rotor shaft to have the predetermined shape, the relative positions of the pair of back yokes can be determined with high accuracy, and the manufacture process can be facilitated.

[0029] Preferably, the polygonal holes each have a polygonal shape depending on the arrangement of the plurality of magnets, and the magnets are positioned to lie on lines extending from the center of rotation of the rotor to pass apexes of the polygonal shape in one-to-one relation.

[0030] By arranging the polygonal holes in such a way, the relative positions of the pair of back yokes can be determined with high accuracy. Further, by arranging the magnets in opposed relation to the apexes of the polygonal hole, the weight of the back yoke can be reduced by cutting out portions of the back yoke which are positioned inward of the plurality of magnets and in which the density of magnetic force lines is low, and thereby reducing the area of the section facing the direction of thickness of the back yoke, as with the above case of forming the holes in the back yoke at positions inward of the magnets.

[0031] Moreover, an electronic device according to the present invention is featured in including any of the electromagnetic transducers described above. More specifically, any of the electromagnetic transducers can be employed as a power generator for supplying power to an electronic device such as an electrically controlled watch or a cellular phone.

[0032] With the above feature of the present invention, because any of the electromagnetic transducers is employed, the weight and size of the electronic device can be reduced corresponding to a reduction in weight and size of the electromagnetic transducer.

[0033] Preferably, any of the electromagnetic transducers is employed as a power supply source of an electronic device in which the rotor is rotated by transmitting kinetic energy accumulated in a main spring to the rotor

through train wheels; for example, an electronically controlled mechanical watch in which a speed-governing function is controlled in an electrical way.

[0034] By employing any of the electromagnetic transducers in such an electronically controlled mechanical watch, since power is only required to be supplied to a circuit section constituting the speed-governing function, the weight and size of the electromagnetic transducer can be further reduced.

[0035] Embodiments of the present invention will now be described by way of further example only and with reference to the accompanying drawings, in which:-

Fig. 1 is a plan view showing the structure of an electronic device utilizing a multipolar power generator according to a first embodiment of the present invention;

Fig. 2 is a sectional view showing the structure of the electronic device according to the first embodiment;

Fig. 3 is a sectional view showing the structure of the multipolar power generator according to the first embodiment;

Fig. 4 is a plan view showing the structure of a stator as one component of the multipolar power generator according to the first embodiment;

Fig. 5 is a block diagram showing the control mechanism of the multipolar power generator according to the first embodiment;

Fig. 6 is a plan view showing a back yoke and magnetic bodies which are components of the multipolar power generator according to the first embodiment;

Fig. 7 is a schematic view for explaining flows of magnetic force lines inside the back yoke in the first embodiment;

Fig. 8 is a plan view showing a back yoke and magnetic bodies which are components of a multipolar power generator according to a second embodiment of the present invention;

Fig. 9 is a schematic view for explaining flows of magnetic force lines inside the back yoke in the second embodiment;

Fig. 10 is a plan view showing a back yoke and magnetic bodies which are components of a multipolar power generator according to a third embodiment of the present invention;

Fig. 11 is a plan view showing a back yoke and magnetic bodies which are components of the multipolar power generator according to a fourth embodiment of the present invention;

Fig. 12 is a schematic view for explaining flows of magnetic force lines inside the back yoke in the fourth embodiment;

Fig. 13 is a schematic view for explaining flows of magnetic force lines inside the back yoke in a fifth embodiment of the present invention;

Fig. 14 is a plan view showing the structure of principal part of an electronic device utilizing a motor according to a sixth embodiment of the present invention;

Fig. 15 is a schematic view representing control of the direction of a current flowing through a coil in the sixth embodiment;

Fig. 16 is a schematic view for explaining flows of magnetic force lines inside a back yoke as one component of a multipolar power generator which is a modification of the fourth embodiment;

Fig. 17 is a plan view showing the structure of an electronic device utilizing a multipolar power generator which is a modification of the first embodiment of the present invention; and

Fig. 18 is a sectional view showing the structure of the electronic device according to the modification of Fig. 17.

[0036] Preferred embodiments of the present invention will be described below with reference to the drawings.

[0037] Fig. 1 is a plan view showing principal part of an electronically controlled mechanical watch as one example of an electronic device utilizing an electromagnetic transducer according to a first embodiment of the present invention.

[0038] Figs. 2 and 3 are sectional views of the principal part.

[0039] The electronically controlled mechanical watch includes a movement barrel 1 comprising a main spring 1a, a barrel gear 1b, a barrel arbor 1c, and a barrel cover 1d. The main spring 1a is fixed at its outer end to the barrel gear 1b and at its inner end to the barrel arbor 1c. The barrel arbor 1c is supported by a main plate 2 and a train wheel bridge 3, and is fixed by a ratchet wheel screw 5 to be rotatable with a ratchet wheel 4.

[0040] The ratchet wheel 4 is held in mesh with a detent 6 so that the ratchet wheel 4 is allowed to rotate in the clockwise direction, but is checked from rotating in the counterclockwise direction. A manner of winding the main spring la by rotating the ratchet wheel 4 in the clockwise direction is similar to that in the automatically or manually winding mechanism in a mechanical watch, and therefore is not described here.

[0041] The rotation of the barrel gear 1b is transmitted to a 2nd (center) wheel 7 after being sped up 7 times, to a 3rd wheel 8 after being sped up 6.4 times, to a 4th (second) wheel 9 after being sped up 9.375 times, to a 5th wheel 10 after being sped up 3 times, to a 6th wheel 11 after being sped up 10 times, and to a rotor 12 after being sped up 10 times, successively. Thus, the rotation of the barrel gear 4 is transmitted through the wheels 7 - 11 which constitute a speed-up train wheel, and is sped up 126,000 times in total.

[0042] An hour pinion 7a is fixed to the 2nd wheel 7, a minute hand 13 for indicating the time of day is fixed to the hour pinion 7a, and a second hand 14 for indicating the time of day is fixed to the 4th wheel 9. Therefore, the rotor 12 is controlled to rotate at 5 rps in order that

the 2nd wheel 7 rotates at 1 rph and the 4th wheel 9 rotates 1 rpm. On this condition, the barrel gear 1b rotates at 1/7 rph.

[0043] The electronically controlled mechanical watch includes a power generator 20 in the form of a multipolar power generator which comprises the rotor 12 and a stator 15.

[0044] The stator 15 fixedly positioned on the main plate 2 is disposed between a pair of back yokes 122 and 123 which are components of the rotor 12. As shown in Fig. 4, the stator 15 comprises a base plate 151 made of an insulating material such as a glass fabric base epoxy resin, and coils 152 wound to occupy an overall thickness of the base plate 151. In such a stator 15, a loss can be reduced because a magnetic circuit comprising the stator 15 has no core generating an iron loss. Also, in the power generator 20 including such a stator 15, the number of windings subject to the magnetic flux can be reduced, and therefore a loss due to coil resistance can also be reduced. Namely, the power generator 20 is a generator capable of taking out a large current with ease.

[0045] The rotor 12 comprises a rotor shaft 121 rotatably held by the main plate 2 and the train wheel bridge 3, a pair of back yokes 122, 123 fixed to the rotor shaft 121, and a plurality of magnets 124, 125 disposed respectively on the pair of back yokes 122, 123 and arranged in opposite relation. The rotor shaft 121 is connected to the main plate 2 and the train wheel bridge 3 through an anti-vibration bearing 31. Though not shown in Figs. 1 to 3, the anti-vibration bearing 31 comprises a double guide cone consisted of a body and a bearing support seat, and a leaf spring provided between the body and the bearing support seat. When an impact, etc. are externally transmitted to the anti-vibration bearing 31 through the main plate 2 and the train wheel bridge 3, the leaf spring absorbs the impact and prevents vibrations from being transmitted to the rotor shaft 121.

[0046] The opposing magnets 124, 125 are arranged such that different poles face to each other, and magnetic force lines L2 generated between the magnets 124 and 125 penetrate the stator 15 interposed between the pair of back yokes 122, 123.

[0047] In addition to the main spring la, the speed-up train wheels 7 - 11, and the power generator, as shown in Fig. 5, the electronically controlled mechanical watch also includes a rectifying circuit 40, a power supply circuit 50, and a rotation control means 60. The electronically controlled mechanical watch is operated and controlled by those components.

[0048] More specifically, the power generator 20 is driven by the main spring 1a through the speed-up train wheels 7 - 11, and produces inductive electromotive forces for supplying electrical energy. The AC power from the power generator 20 is boosted and rectified through the rectifying circuit 40 which functions to perform boosting rectification, full-wave rectification, half-wave rectification, transistor rectification, or the like. The rectified power is supplied to and charged in the power supply circuit 50 comprising a capacitor or the like. In this embodiment, though not shown in Figs. 1 - 5, the power generator 20 is provided with a brake circuit including the rectifying circuit 40. The brake circuit serves to carry out speed governing of the minute hand 13, the second hand 14, etc.

[0049] The brake circuit is controlled by the rotation control means 60 driven with power that is supplied from the power supply circuit 50. As shown in Fig. 5, the rotation control means 60 comprises an oscillation circuit 61, a detection circuit 62 and a control circuit 63.

[0050] The oscillation circuit 61 outputs a reference signal fs of 5 Hz using a quartz oscillator 61A as a time standard source.

[0051] The detection circuit 62 comprises a waveform shaping circuit and a monomultivibrator which are connected to the power generator 20. The waveform shaping circuit comprise an amplifier and a comparator, and transforms a sinusoidal wave into a rectangular wave. The monomultivibrator functions as a band-pass filter allowing pulses having a period not less than a certain value to pass through the same, and outputs a rotation detection signal FG1 deprived of noise.

[0052] The control circuit 63 comprises an up-and-down counter, a synchronizing circuit, and a chopper circuit. The control circuit 63 receives the reference signal fs from the oscillation circuit 61 and the rotation detection signal FG1 from the detection circuit 62, and based on those signals fs and FG1, controls the brake circuit.

[0053] As shown in Fig. 6, the back yoke 122 as one component of the rotor 12 is constituted by a disk made of soft iron. Six magnets 124 are disposed on the surface of the back yoke 122 in symmetrical fashion about the rotary shaft, and these magnets 124 are arranged with N and S poles arrayed alternately in the direction of rotation. Further, in a portion of the back yoke 122 where each magnet 124 is positioned, a cutout 122a is formed to extend from the outer periphery of the back yoke 122 toward the center of rotation and to pass the center of the magnetic pole of each magnet 124.

[0054] As shown in Fig. 7 which is a side view of the back yoke and the magnets shown in Fig. 6, the cutout 122a is formed in a portion where the density of magnetic force lines is low depending on distribution of magnetic force lines L1 produced inside the back yoke 122 by the adjacent magnets 124. A width W1 of the cutout 122a is selected so as to avoid saturation of the magnetic flux in a close contact portion of the back yoke 122 and the magnet 124, and to prevent a reduction of the density of the magnetic force lines L2 which are radiated from an upper surface of the magnet 124.

[0055] The back yoke 123 and the magnets 125 also have substantially the same structure as that of the back yoke 122 and the magnets 124, but the back yoke 123 is mounted 60° out of phase in the rotating direction of the rotor 12 with respect to the mount position of the back yoke 122 to the rotor shaft 121. The opposing mag-

nets 124 and 125 are arranged such that different poles face to each other.

[0056] The operation of the above-described power generator 20 will be next described.

(1) The movement barrel 1 is rotated with unwinding motion of the main spring 1a, and the rotor 12 is rotated through the speed-up train wheels 7 - 11.
(2) Upon the rotation of the rotor 12, the magnetic force lines L2 penetrating the stator 15 are successively changed above and below the stator 15 due to the rotating magnets 124 and 125 with N and S poles arrayed alternately in the direction of rotation. Correspondingly, an induced current is produced in each coil 152 formed on the stator 15.
(3) The induced current produced in the stator 15 is supplied to the rotation control means 60 through the rectifying circuit 40 and the power supply circuit 50. Then, the rotation control means 60 controls the operation of the brake circuit to perform speed governing of the electronically controlled mechanical watch.

[0057] The above-described power generator 20, i.e., the multipolar power generator according to the first embodiment, has advantages as follows.

[0058] Since the cutouts 122a are formed in the back yoke 122, the weight of the back yoke 122 can be reduced and hence the overall weight of the rotor 12 can be reduced. Correspondingly, the rotor shaft 121 can be thinned and the efficiency of power generation can be improved. In addition, a reduction of the weight of the rotor 12 contributes to simplifying and downsizing the structure of the anti-vibration bearing 31, thus resulting in a reduction of both size and weight of the power generator 20.

[0059] Also, since the rotor 12 comprises the plurality of magnets 124, 125 arranged on the back yokes 122, 123, the rotor 12 can be constructed by arranging the magnets 124, 125 in the least necessary portions. Consequently, the weight of the power generator 20 can be further reduced.

[0060] Since an sectional area of each back yoke 122, 123 in the direction of thickness thereof is reduced by forming the cutouts 122a to extend from the outer periphery of the back yoke 122, 123 toward the center of rotation, the weight of the back yoke 122, 123 can be reduced by simple machining, and therefore manufacture of the rotor 12 can be simplified.

[0061] Since the cutouts 122a are formed at the centers of the magnetic poles of the magnets 124, 125 where the density of magnetic force lines L1 is low, the magnetic flux is avoided from being saturated in the close contact portions of the back yokes 122, 123 and the magnets 124, 125. As a result, the weight of the rotor 12 can be reduced without diminishing the density of the magnetic force lines L2 which are radiated from the magnets 124, 125.

[0062] Additionally, since the power generator 20 having the above construction is provided in the electronically controlled mechanical watch, the size and thickness of the electronically controlled mechanical watch can also be reduced based on a reduction in size and thickness of the power generator 20.

[0063] A multipolar power generator according to a second embodiment of the present invention will be described below. Components or members which have been described above are denoted by the same numerals in the following, and their description is omitted or abridged.

[0064] In the above first embodiment, the weight of the back yokes 122, 123 is reduced by forming the cutouts 122a to extend from the outer periphery of the disk toward the center of rotation and arranging the magnets 124, 125 to position above the cutouts 122a.

[0065] A back yoke 222 which is one component of a rotor of the multipolar power generator according to the second embodiment differs from that in the first embodiment as follows. As shown in Figs. 8 and 9, the back yoke 222 is constituted by an annular magnetic body 224 of which the surface is magnetized into six poles. The weight of the back yoke 222 is reduced by forming recesses 222a in one surface opposed to the other surface thereof which is in close contact with the annular magnetic body 224.

[0066] Referring to Fig. 8, the annular magnetic body 224 is magnetized into six poles 224N and 224S such that the N and S poles are alternately arrayed in each of upper and lower surfaces. The recesses 222a formed in the back yoke 222 are in the form of grooves positioned at the centers of the magnetic poles 224N and 224S and extended from the outer periphery of the back yoke 222 toward the center of rotation. As shown in Fig. 9, the recesses 222a are formed in one surface of the back yoke 222 opposed to the other surface thereof which is in close contact with the annular magnetic body 224, and the section of each recess 222a is tapered to gradually narrow toward the bottom of the recess. As with the first embodiment, an opening width W2 of the recess 222a can be selected to a larger value so long as the opening is positioned in an area where the density of magnetic force lines L3 is low, and so long as the magnetic flux is not saturated in a close contact portion of the back yoke 222 and the annular magnetic body 224, i.e., the density of magnetic force lines L4 radiated from the magnetic poles 224N, etc. is not diminished.

[0067] The other structure and operation of the multipolar power generator are similar to those of the multipolar power generator 20 according to the first embodiment, and therefore are not described here.

[0068] The second embodiment described above has the following advantages in addition to those of the first embodiment.

[0069] Since the magnetic body is formed by magnetizing each surface of the annular magnetic body 224 into six poles, the multipolar structure of the rotor can be

formed just by attaching one piece of the annular magnetic body 224 onto the back yoke 222, and therefore manufacture of the multipolar power generator can be simplified.

[0070] Further, since the magnetic body 224 is in the annular form, the strength of the disk is less impaired with the recesses 222a formed in the rear surface of the back yoke 222 for reducing the weight of the back yoke 222. In addition, a close contact area between the annular magnetic body 224 and the back yoke 222 can be ensured sufficiently. A third embodiment of the present invention will be described below.

[0071] In the multipolar power generators according to the above first and second embodiments, the weight of the back yokes 122, 222 is reduced by forming the cutouts 122a or recesses 222a in the back yokes 122, 222.

[0072] A multipolar power generator according to this third embodiment differs from those according to the first and second embodiments as follows. As shown in Fig. 10, the weight of a back yoke 322 is reduced with the provision of recesses 322a formed by cutting out an outer peripheral edge of the back yoke 322 at positions depending on a plurality of magnets 124 disposed on the back yoke 322, and holes 322b formed inward of the magnets 124 disposed on the back yoke 322.

[0073] In Fig. 10, the recesses 322a are each positioned outward of each magnet 124 so as to gradually open from the center O of rotation of the back yoke 322, and the bottom of the recess 322a lies on a line connecting the center O of rotation and the center of poles of the magnet 124. The holes 322b are each formed inward of each magnet 124, and the center of the hole 322b lies on the line connecting the center O of rotation and the center of poles of the magnet 124. As seen from Fig. 10, the recesse 322a and the hole 322b are formed in an area where the density of magnetic force lines L5 produced between the N and S poles of the adjacent magnets 124 along the surface of the back yoke 322 is low.

[0074] The other structure and operation of the multipolar power generator according to the third embodiment are similar to those of the multipolar power generator 20 according to the first embodiment, and therefore are not described here.

[0075] The multipolar power generator according to the third embodiment described above has the following advantages in addition to those of the first embodiment.

[0076] Since the recesses 322a and the holes 322b are formed in the back yoke 322 in two-dimensional fashion, a larger cutout area of the back yoke 322 can be securely obtained, and the weight of the rotor, including the back yoke 322, can be much reduced. It is therefore possible to further improve the power generation efficiency of the multipolar power generator, and reduce the weight and size thereof.

[0077] A fourth embodiment of the present invention will be described below.

[0078] In the above first embodiment, the weight of the back yoke 122 is reduced by forming the cutouts 122a to extend from the outer periphery of the back yoke 122 toward the center of rotation at positions depending on the arrangement of the magnets 124, and lessening a sectional area of the back yoke 122 in the direction of thickness thereof.

[0079] In this fourth embodiment, as shown in Figs. 11 and 12, a sectional area of a back yoke 422 in the direction of thickness thereof is reduced by forming recesses 422a in the back yoke 422 at predetermined positions.

[0080] Columnar magnets 424 are fitted into the recesses 422a formed in the back yoke 422 with a substantially lower half of each magnet embedded in the back yoke 422, as shown in Fig. 12. The depth of each recess 422a is set to such a dimension that when the magnet 424 is fitted in place, a boundary 424c between poles of the magnet 424 slightly projects from the surface of the back yoke 422. Magnetic force lines L6 passing inside the back yoke 422 flow into the magnet 424 from bottom and side surfaces thereof on the lower S-pole side, and magnetic force lines L7 radiates upward from the upper N-pole side.

[0081] Also, while a central hole of the back yoke 122 in which the rotor shaft 121 is inserted is circular in the above first embodiment, a central hole 422b of the back yoke 422 is hexagonal in this third embodiment as seen from Fig. 11. Corresponding to the hexagonal hole 422b, the rotor shaft is formed to have a hexagonal radial section (though not shown). The central hole 422b and the rotor shaft both being hexagonal cooperate to constitute a positioning means for positioning a pair of back yokes 422 relative to each other.

[0082] Further, the recesses 422a are formed to lie on respective lines radially extending from the center of rotation while passing six apexes of the hexagonal hole 422b, and the centers of the circular recesses 422a are positioned to lie on the respective lines.

[0083] When manufacturing the rotor according to this embodiment, the back yoke 422 having the recesses 422a and the holes 422b formed therein is first molded by casting, and the magnets 424 are then fitted into the recesses 422a. In the magnet fitting step, the magnets 424 can be securely mounted on the back yoke 422 without using an adhesive because the magnets 424 are restricted from moving along the surface of the back yoke 422 held in close contact with the magnets into the recesses 422a, and the magnets 424 adhere to the back yoke 422 under attraction with magnetic forces produced by the magnets 424.

[0084] Two pieces of the back yokes 422 including the magnets 424 thus mounted thereon are fitted over the rotor shaft and fixed with the two back yokes 422 being 60° out of phase from each other. The two back yokes 422 are thereby automatically positioned such that N and S poles are opposed to each other. The other structure and operation are similar to those of the first em-

bodiment, and therefore are not described here.

[0085] The fourth embodiment described above has the following advantages in addition to those of the first embodiment.

[0086] Since the magnets 424 are fitted into the recesses 422a, a contact area between the magnets 424 and the back yoke 422 is increased. Accordingly, the magnetic force lines L6 inside the back yoke 422 flow into the magnets 424 more easily, and the magnetic force lines L7 radiated from the magnets 424 are increased, thus resulting in a multipolar power generator which has higher efficiency of power generation.

[0087] Also, movement of the magnets 424 along the surface of the back yoke 422 held in close contact with the magnets can be restricted due to fitting of the magnets 424 into the recesses 422a of the back yoke 422, and movement of the magnets 424 in the direction outward of the surface of the back yoke 422 can be restricted under attraction of magnetic forces produced by the magnets 424. Therefore, the magnets 424 can be held on the back yoke 422 with no need of bonding the magnets 424 to the back yoke 422 using an adhesive or the like. This increases the efficiency in manufacture of the rotor including the back yoke 422. Additionally, when the multipolar power generator including the rotor according to this embodiment is used in portable electronic devices, such as a watch and a cellular phone, and the magnets 424 may possibly detach from the back yoke 422 due to vibrations, the detachment of the magnets can be surely prevented by using an adhesive or the like.

[0088] Further, since the depth of each recess 422a is set to such a dimension that the boundary 424c between poles of the magnet 424 slightly projects from the surface of the back yoke 422, the magnetic poles are not susceptible to twisting or the like. Accordingly, the magnetic force lines L6 inside the back yoke 422 are allowed to smoothly flow into the magnets 424, and the magnetic force lines L7 radiated from the magnets 424 to penetrate the coils can be increased. As a result, a multipolar power generator with higher efficiency of power generation can be achieved.

[0089] Since the recesses 422a and the magnets 424 are circular in plan view, manufacture of the back yoke 422 and the magnets 424 can be facilitated.

[0090] With the provision of the positioning means comprising the hexagonal rotor shaft and the hexagonal hole 422b formed in the back yoke 422, relative positions of the back yokes 422 in pair can be set so that magnetic force lines flow most efficiently, and therefore great changes of magnetic flux can be applied to the coils between the pair of the back yokes 422.

[0091] Since the positioning means comprises the hole 422b and the rotor shaft being both hexagonal, the rotor positioned with high accuracy can be easily manufactured.

[0092] Additionally, since the magnets 424 are arranged in opposed relation to the apexes of the hexagonal hole 422b, a sectional area of the back yoke 422 in the direction of thickness thereof can be reduced by cutting out portions of the back yoke 422 where the density of magnetic flux produced by the plurality of magnets 424 is low, and the weight of the back yoke 422 can be further reduced as with the third embodiment.

[0093] A fifth embodiment of the present invention will be described below.

[0094] In the rotor as one component of the multipolar power generator according to the fourth embodiment, the columnar magnets 424 are employed and the columnar recesses 422a are formed to receive the magnets 424 for mutual fitting.

[0095] A rotor as one component of a multipolar power generator according to the fifth embodiment differs from the rotor in the fourth embodiment as follows. As shown in Fig. 13, recesses 522a formed in a back yoke 522 are each configured such that a width W2 of each recess 522a in the direction perpendicular to the direction of depth thereof gradually decreases toward the bottom of the recess. Also, a magnet 524 fitted into each of the recesses 522a is configured corresponding to the shape of the recess 522a.

[0096] The magnet 524 has a rectangular shape in plan view, and its fore end portion has a triangular shape in side view. Slopes of the triangular shape are extended in the direction perpendicular to magnetic force lines L8 inside the back yoke 522 so that the magnetic force lines L8 smoothly flow into the magnet 524. The other structure is similar to that of the fourth embodiment, and therefore is not described here.

[0097] The multipolar power generator provided with the rotor according to the fifth embodiment described above has the following advantages in addition to those of the fourth embodiment.

[0098] With the recess 522a having the shape described above, the magnetic force lines L8 passing inside the back yoke 522 smoothly flow into the magnet 524 into the direction perpendicular to slopes of a portion of the magnet 524 which is fitted into the recess 522a, and magnetic force lines L8 radiated from the magnet 524 to penetrate the coil are further increased. Accordingly, by using the rotor including the above-described back yoke 522, a multipolar power generator with higher efficiency of power generation can be achieved.

[0099] A sixth embodiment of the present invention will be described below.

[0100] In the above first to fifth embodiments, the electromagnetic transducer according to the present invention is utilized as a multipolar power generator.

[0101] On the other hand, in this sixth embodiment, the electromagnetic transducer according to the present invention is utilized as a motor.

[0102] As shown in Fig. 14 which illustrates the principal structure, an electronically controlled watch according to this embodiment comprises train wheels 7 - 11 and a rotor 12 similarly to the first embodiment, but includes a battery 70 instead of the movement barrel

accommodating the main spring. Electrical energy from the battery 70 is supplied to a motor 80 to rotate the rotor 12. With the rotation of the rotor 12, the train wheels 7 - 11 are rotated to operate a minute hand attached to the wheel 7 and a second hand attached to the wheel 9.

[0103] The motor 80 has the same structure as the multipolar power generator 20 according to the first embodiment (see Fig. 3). A stator similar to that in the first embodiment is disposed between a pair of back yokes which are components of the rotor 12 (see Fig. 4). A current from the battery 70 flows through coils formed on a base plate of the stator, whereupon a magnetic field is generated to rotate the rotor 12. More specifically, as shown in Fig. 15, three coils 152 formed on the base plate of the stator are connected in series, thereby constituting a drive circuit 90. The drive circuit 90 is connected at one end to a positive (+) terminal of the battery 70 and at the other end to a negative (-) terminal thereof.

[0104] The drive circuit comprises the three coils 152 connected in series, two P-channel MOS transistors 91, 92, and two N-channel MOS transistors 93, 94. Gates 911, 921, 931, 934 of these transistors 91 - 94 serve as input terminals. By applying a low- or high-level voltage to the gates 911, 921, 931, 934, the direction of a current flowing through the coils 152 is changed. Specifically, a current flows through the coils 152 as follows.

(1) When the voltages applied to the gates 911, 921, 931, 934 are all at a low level, the two P-channel MOS transistors 91, 92 are turned on to constitute a closed circuit including the coils 152. At this time, no current flows through the coils 152 and therefore no effects are applied to the rotor 12.

(2) When the voltages applied to the gates 911, 931 are turned to a high level in the above condition, a current flows through the coils 152 as indicated by an arrow in Fig. 15, whereupon the magnetic field near the stator is changed to rotate the rotor 12. Then, the rotor 12 is going to stop in a balanced position.

(3) When the voltages applied to the gates 911, 931 are returned to a low level and the voltages applied to the gates 921, 941 are turned to a high level on the contrary to the above condition, a current flows through the coils 152 in a reversed condition. The magnetic field is thereby generated in a reversed condition to further rotate the rotor 12.

[0105] By changing a combination of switching currents applied to the transistors 91 - 94 in such a manner, the rotor 12 is continuously rotated, causing the minute hand and the second hand to operate.

[0106] The sixth embodiment described above has the advantages below.

[0107] By providing the battery 70 and the drive circuit 90, the electromagnetic transducer having the same structure as the multipolar power generator 20 according to the first embodiment can be used as the motor 80.

[0108] Also, by employing the motor 80 to construct an electronically controlled watch, the rotor 12 can be continuously rotated because the weight of the rotor 12 including the back yokes is reduced. An electronically controlled watch capable of moving the second hand continuously can be therefore realized. This result contributes to eliminating such a dissatisfaction of users experienced in electronically controlled watches having second hands moved intermittently that the second hand is often not stopped precisely at gradations formed at pitch of 6° on a dial due to errors in manufacture.

[0109] It is to be noted that the present invention is not limited to the above embodiments, but includes the following modifications as well.

[0110] While in the above fourth embodiment the recess 522a is rectangular in plan view and triangular in side view, the present invention is not limited to such a shape of the recess 522a. Specifically, as shown in Fig. 16, a recess 622a may be formed in a back yoke 622 to have a circular shape in plan view with its bottom curved along a circumference, and a portion of a magnet 624 which is fitted into the recess 622a may be formed to have a spherical shape.

[0111] By forming the recess 622a into such a shape, the direction of incidence of magnetic force lines L10 from the back yoke 622 to the magnet 624 can be aligned with the direction normal to the spherical surface of the magnet 624, and magnetic force lines L11 radiated from the magnet 624 can be further increased.

[0112] While, in the multipolar power generator 20 according to the first embodiment, the stator 15 including the coils 152 formed thereon is interposed between the back yokes 122 and 123, the present invention is not limited to such a structure. Specifically, as shown in Figs. 17 and 18, the present invention may use a stator 115 constituted by interposing only a stator member 115a between the back yokes 122 and 123, and winding a stator coil 115b over a separate stator member 115.

[0113] Since only the stator member 115a is interposed between the back yokes 122 and 123, the structure of such a multipolar power generator 120 is advantageous in reducing the thickness of the multipolar power generator 120. Further, as shown in Fig. 17, a magnetic core 116a may be connected to the stator member 115a in addition to the stator member 115, and a coil 116b may be wound over the magnetic core 116a to form a coil block 116, the coil 116b being connected to the stator coil 115b in series, for example. With such an arrangement, an output voltage of the multipolar power generator 120 can be set to various values. In the case of the multipolar power generator 120, however, the number of windings of the stator coil 115b and the coil 116b is preferably set to about 15,000 turns in consideration of coil resistance, etc.

[0114] While in the first embodiment the magnetic body comprises a plurality of magnets 124 and the cutouts 122a are formed to extend from the outer periphery of the back yoke 122 toward the center of rotation, the

present invention is not limited to such a structure. More specifically, similar advantages to those in the first embodiment can also be obtained in the case of combining the back yoke including the cutouts formed therein with the annular magnetic body 224 used in the second embodiment.

[0115] While in the second embodiment the annular magnetic body 224 is held in close contact with the front surface of the back yoke 222 having the recesses 222a formed in the rear surface thereof, a magnetic body comprising a plurality of magnets may be arranged on the back yoke 222.

[0116] While in the third embodiment the holes 322b are formed in a circular shape, the shape of the holes 322b is not limited to a circle, but may be oblong. In other words, the shape and dimension of the holes 322b can be determined appropriately depending on distribution of the magnetic force lines L5.

[0117] While in the first embodiment the rotor 12 is rotated upon unwinding motion of the main spring la, the present invention is not limited to such a structure. As an alternative, the rotor may be rotated by transmitting rotation of a rotating weight through the train wheels, etc. Thus, the present invention can be utilized to any type of multipolar power generator wherein a rotor is rotated with mechanical energy in any form.

[0118] While in the first embodiment the multipolar power generator 20 is used as a power supply source for the electronically controlled mechanical watch, the present invention is not limited to such an application. The present invention is also applicable to another type of electronic device such as a cellular phone.

[0119] Further, the methods of reducing the weight of the back yoke, which have been described in the first to fifth embodiments, can also be applied to the motor according to the sixth embodiment. The driving efficiency of the motor can be remarkably improved by employing the back yoke having the thus-reduced weight.

[0120] While in the electromagnetic transducers according to the first to sixth embodiments the magnetic body is provided on each of the paired back yokes, the present invention is not limited to such a structure. The magnetic body may be provided on only one of the paired back yokes, whereas no magnetic body may be provided on the other. In this modification, any of the methods of reducing the weight of the back yoke, which have been described in the first to sixth embodiments, can also be applied to the one of the paired back yokes including the magnetic body.

[0121] It should be understood that concrete structures, shapes, etc. used in implementing the present invention can be modified in various ways within the scope of achieving the object of the present invention.

[0122] According to the multipolar power generator of the present invention, as described above, since a sectional area of the back yoke is reduced to such an extent that the magnetic flux passing inside the back yoke is not saturated, the weight of the back yoke can be reduced and hence the overall weight of the rotor can be reduced. It is therefore possible to thin the rotor shaft and to improve the efficiency of power generation and the driving efficiency of a motor.

Claims

1. An electromagnetic transducer comprising a rotor and a coil and transducing kinetic energy generated due to rotation of said rotor and electrical energy generated in said coil,

   wherein said rotor comprises a rotor shaft serving as the center of rotation, and a back yoke including a magnetic body with N and S poles arrayed in the direction of rotation of said rotor, said magnetic body being held in close contact with said back yoke, and
   said back yoke is formed such that an area of a section of said back yoke sectioned by a plane passing the center of said magnetic body as viewed in plan and said rotor shaft is smaller than a sectional area of another portion of said back yoke depending on distribution of magnetic force lines generated inside said back yoke.

2. An electromagnetic transducer according to Claim 1, wherein said magnetic body is constructed by magnetizing a surface of an annular magnetic body into a plurality of poles.

3. An electromagnetic transducer according to Claim 1, wherein said magnetic body is constructed by a plurality of magnets with N and S poles arrayed alternately on said back yoke.

4. An electromagnetic transducer according to any one of Claims 1 to 3, wherein cutouts are formed in said back yoke to extend from an outer periphery of said back yoke toward the center of the rotation and to pass the centers of the poles of said magnetic body in one-to-one relation.

5. An electromagnetic transducer according to any one of Claims 1 to 3, wherein recesses are formed in one surface of said back yoke opposed to the other surface thereof, which is held in contact with said magnetic body, in one-to-one relation to the centers of the poles of said magnetic body.

6. An electromagnetic transducer according to Claim 3, wherein cutouts are formed in an outer peripheral edge of said back yoke at positions depending on the arrangement of said plurality of magnets on said back yoke.

7. An electromagnetic transducer according to Claim

3 or 6, wherein holes are formed in said back yoke at positions depending on the arrangement of said plurality of magnets on said back yoke inward of said magnets.

8. An electromagnetic transducer according to Claim 3, wherein a plurality of recesses are formed in said back yoke to receive said plurality of magnets for mutual fitting in one-to-one relation.

9. An electromagnetic transducer according to Claim 8, wherein said recesses are each formed such that a width of each recess in the direction perpendicular to the direction of depth thereof gradually decreases toward the bottom of the recess, and a portion of each of said magnets which is fitted into each recess is configured corresponding to the shape of the recess.

10. An electromagnetic transducer according to Claim 8 or 9, wherein the depth of said recesses is set depending on a boundary between the poles of each of said magnets fitted into said recesses.

11. An electromagnetic transducer according to any one of Claims 8 to 10, wherein said recesses and said magnets are formed to have a circular shape in plan view.

12. An electromagnetic transducer according to any one of Claims 1 to 11, wherein said rotor includes a pair of back yokes arranged in opposed relation with coils disposed therebetween, and said rotor shaft includes positioning means for determining relative positions of said pair of back yokes.

13. An electromagnetic transducer according to Claim 12, wherein poles of a magnetic body arranged on one of said pair of back yokes differ from poles of another magnetic body arranged on the other back yoke in opposed relation.

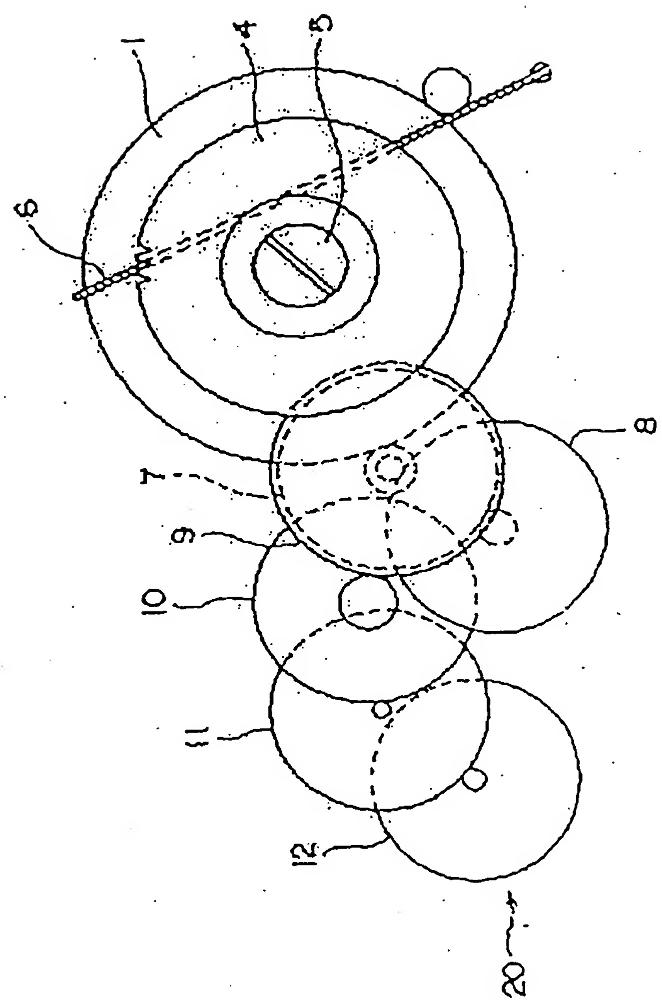
14. An electromagnetic transducer according to Claim 12 or 13, wherein said positioning means includes a rotor shaft formed to have a polygonal shape in a radial section, and polygonal holes formed in said pair of back yokes to receive said rotor shaft for mutual fitting.

15. An electromagnetic transducer according to Claim 14, wherein said polygonal holes each have a polygonal shape depending on the arrangement of said plurality of magnets, and said magnets are positioned to lie on lines extending from the center of rotation of the rotor to pass apexes of said polygonal shape in one-to-one relation.

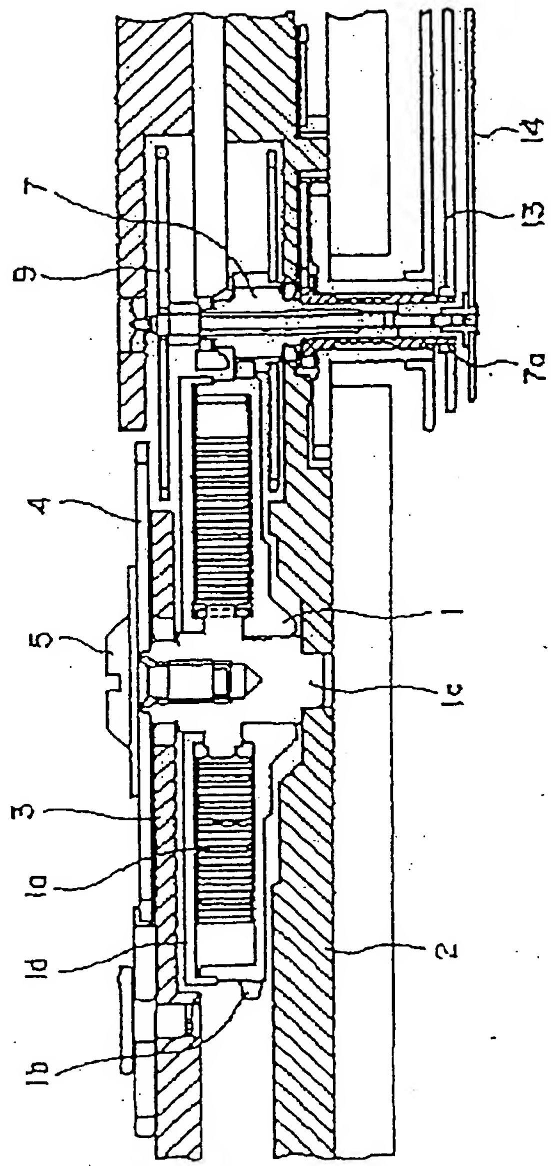
16. An electronic device including said electromagnetic transducer according to any one of Claims 1 to 15.

17. An electronic device according to Claim 16, wherein said rotor is rotated by transmitting kinetic energy accumulated in a main spring to said rotor through train wheels.

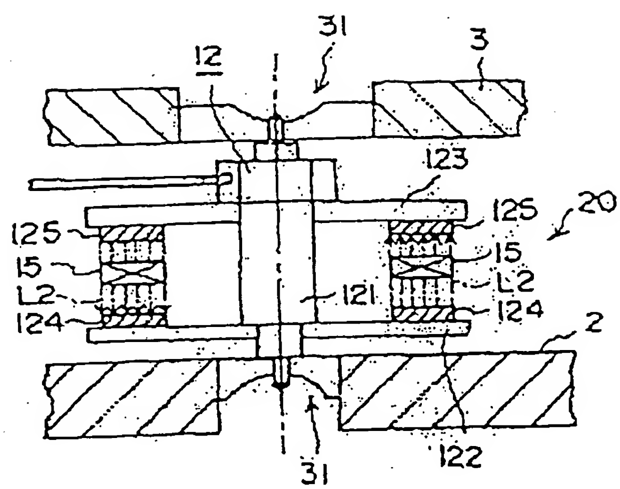
[FIG. 1]



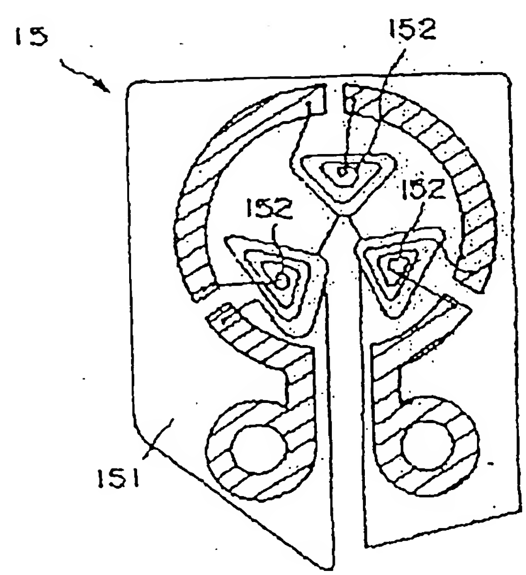
[FIG. 2]



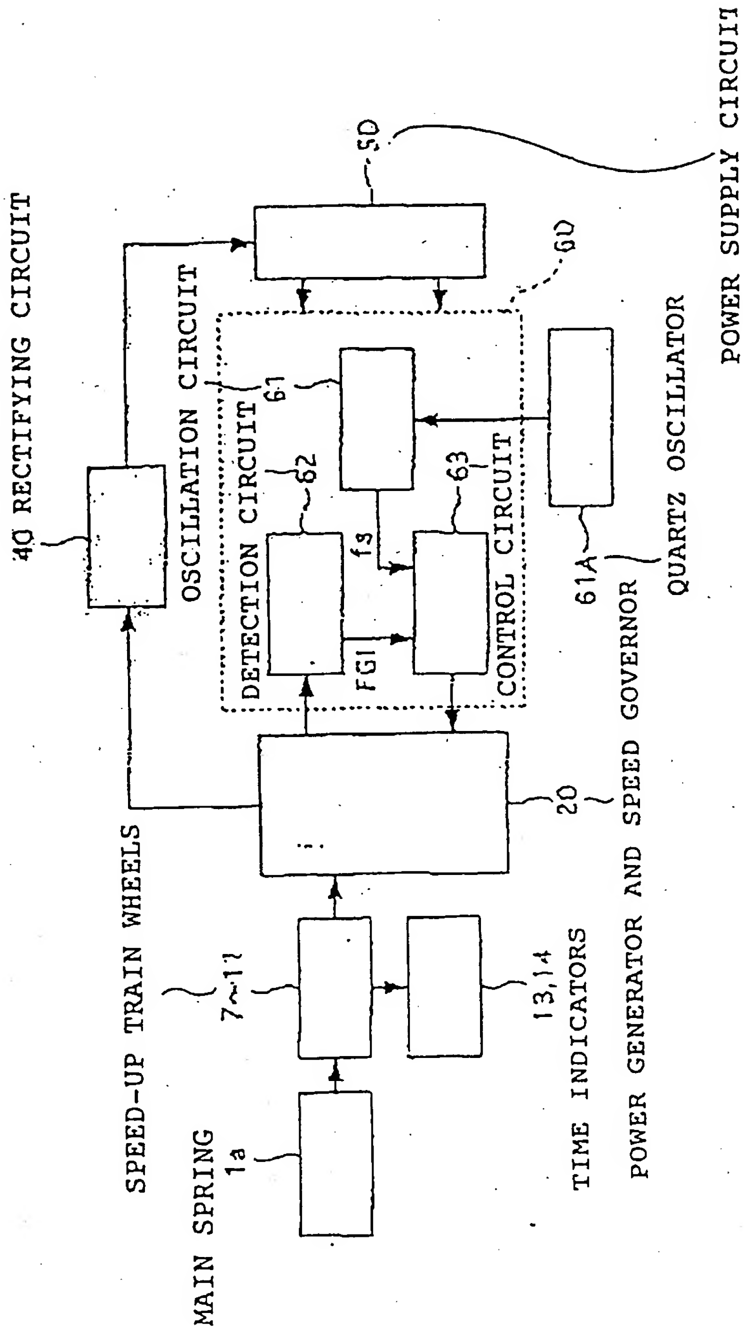
[FIG. 3]


31
3
12
123
125
20
125
15
15
L2
L2
121
124
124
2
122
31

[FIG. 4]

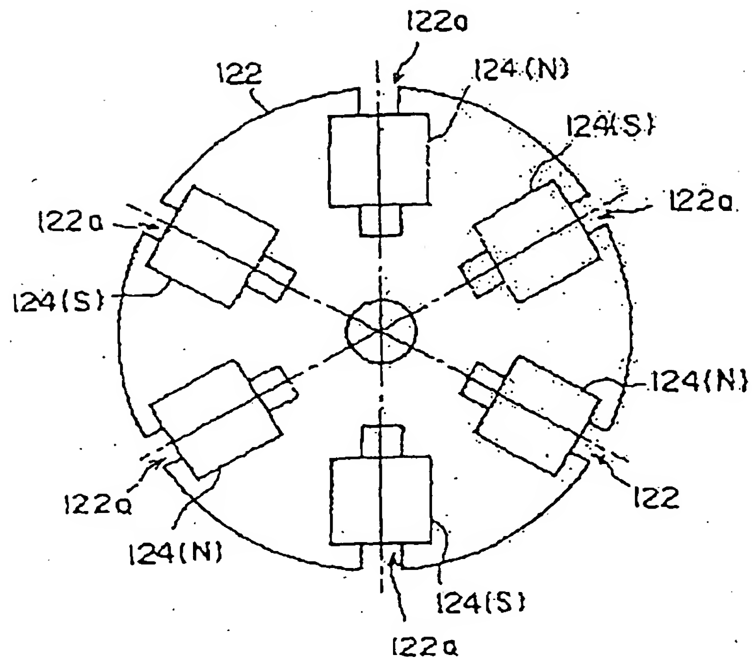

15
152
152
152
151

[FIG. 5]

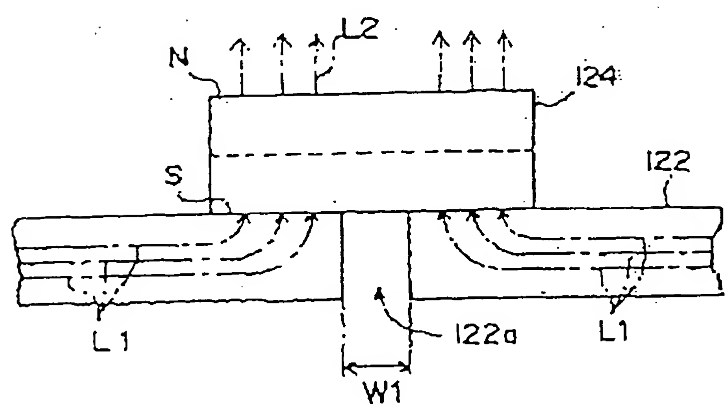


MAIN SPRING
1a
SPEED-UP TRAIN WHEELS
7~11
TIME INDICATORS
13,14
POWER GENERATOR AND SPEED GOVERNOR
20
40 RECTIFYING CIRCUIT
50
POWER SUPPLY CIRCUIT
60
OSCILLATION CIRCUIT
61
DETECTION CIRCUIT
62
CONTROL CIRCUIT
63
fs
FG1
61A
QUARTZ OSCILLATOR

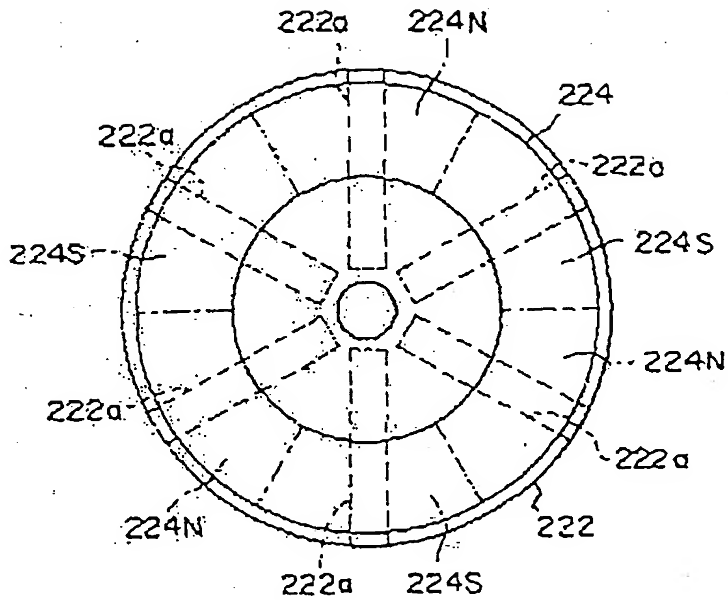
[FIG. 6]


122a
122
124(N)
124(S)
122a
122a
124(S)
124(N)
122a
122
124(N)
124(S)
122a

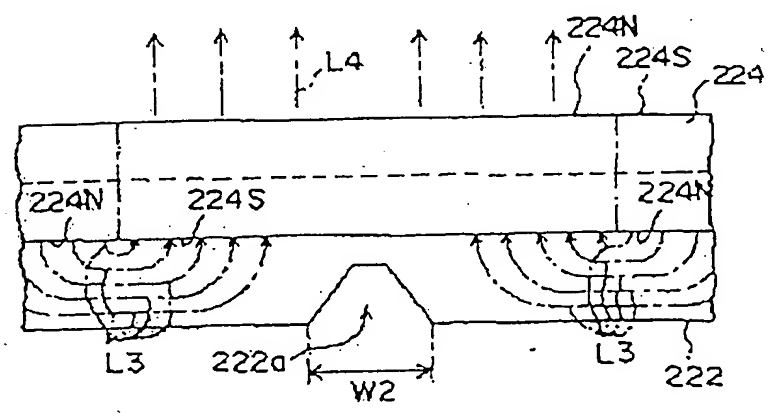
[FIG. 7]


N
L2
124
122
S
L1
122a
L1
W1

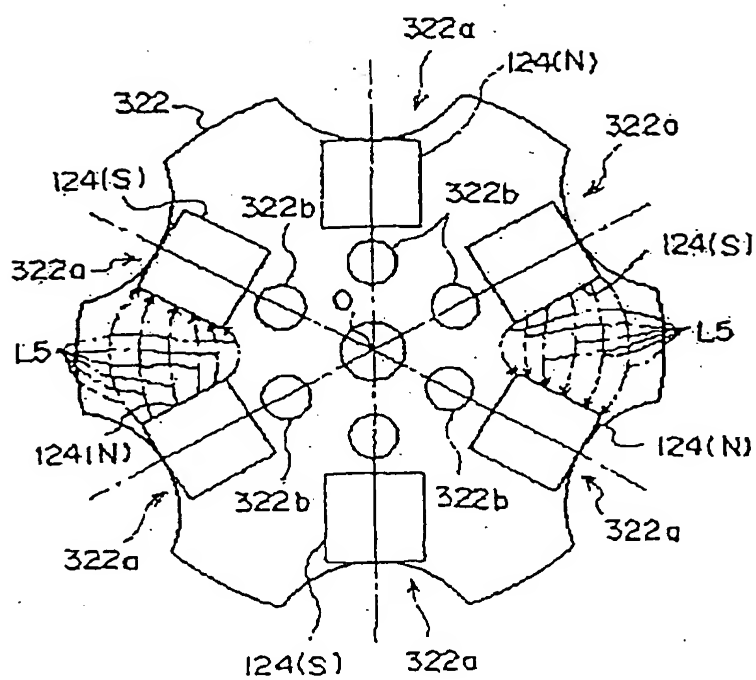
[FIG. 8]


222a
224N
224
222a
222a
224S
224S
224N
222a
222a
224N
222
222a
224S

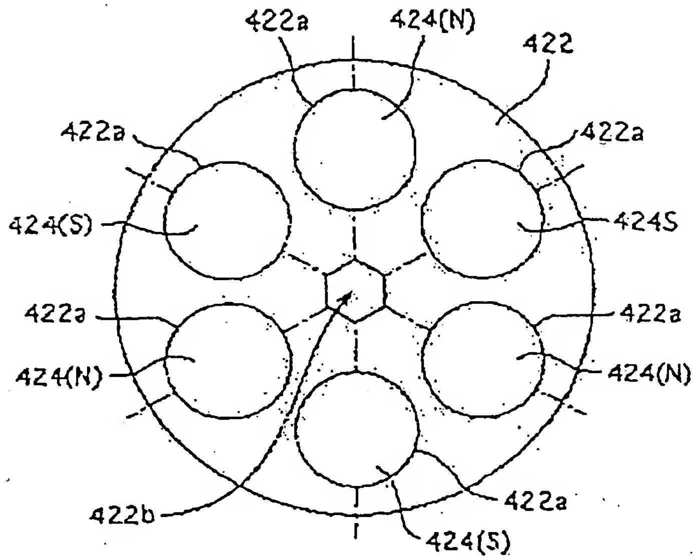
[FIG.9]


224N
L4
224S
224
224N
224S
224N
L3
222a
W2
L3
222

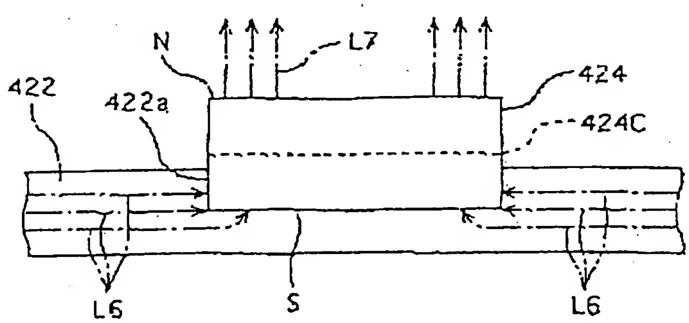
[FIG. 10]


322a
124(N)
322
322a
124(S)
322b
322b
124(S)
322a
O
L5
L5
124(N)
124(N)
322b
322b
322a
322a
124(S)
322a

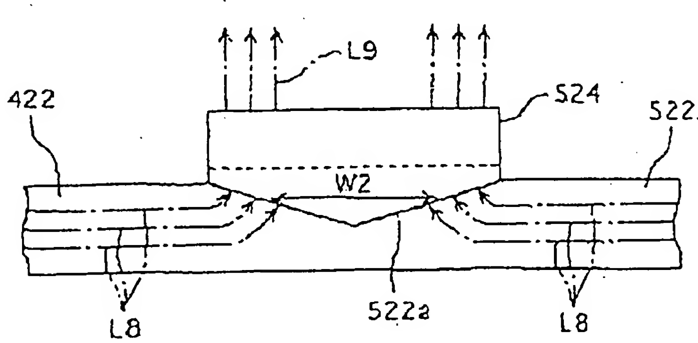
[FIG. 11]



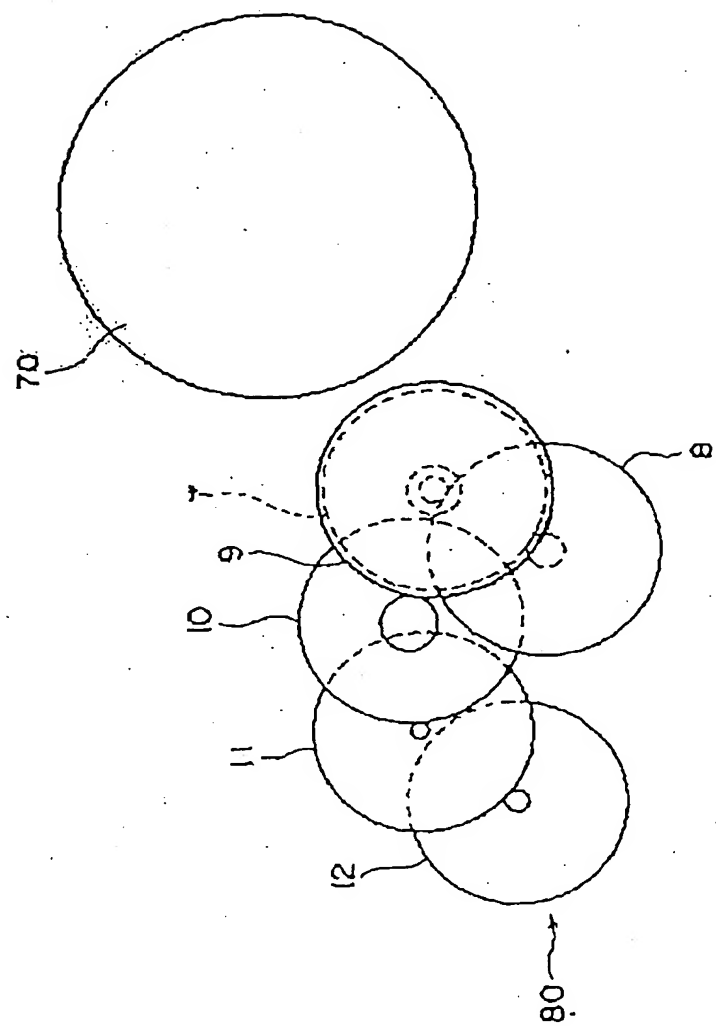
[FIG. 12]



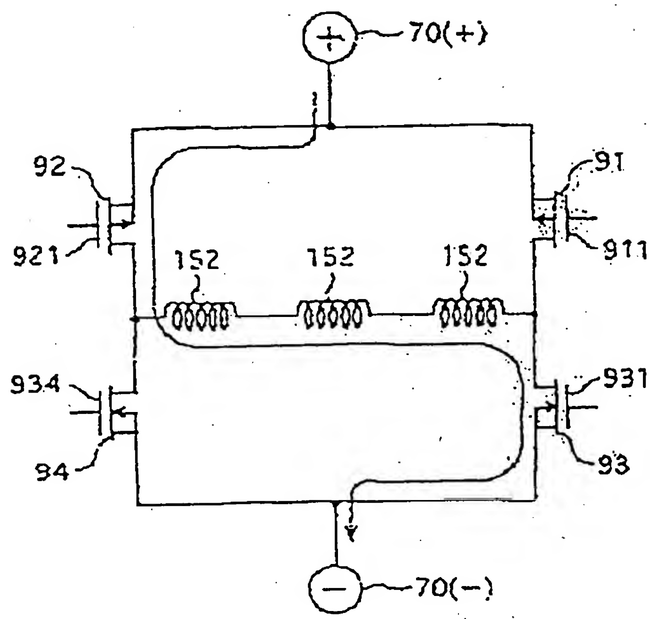
[FIG. 13]



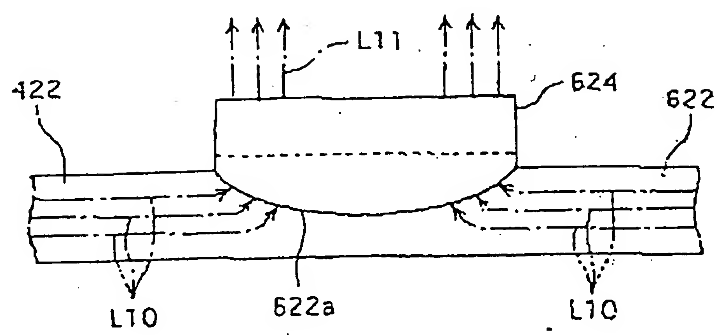
[FIG. 14]



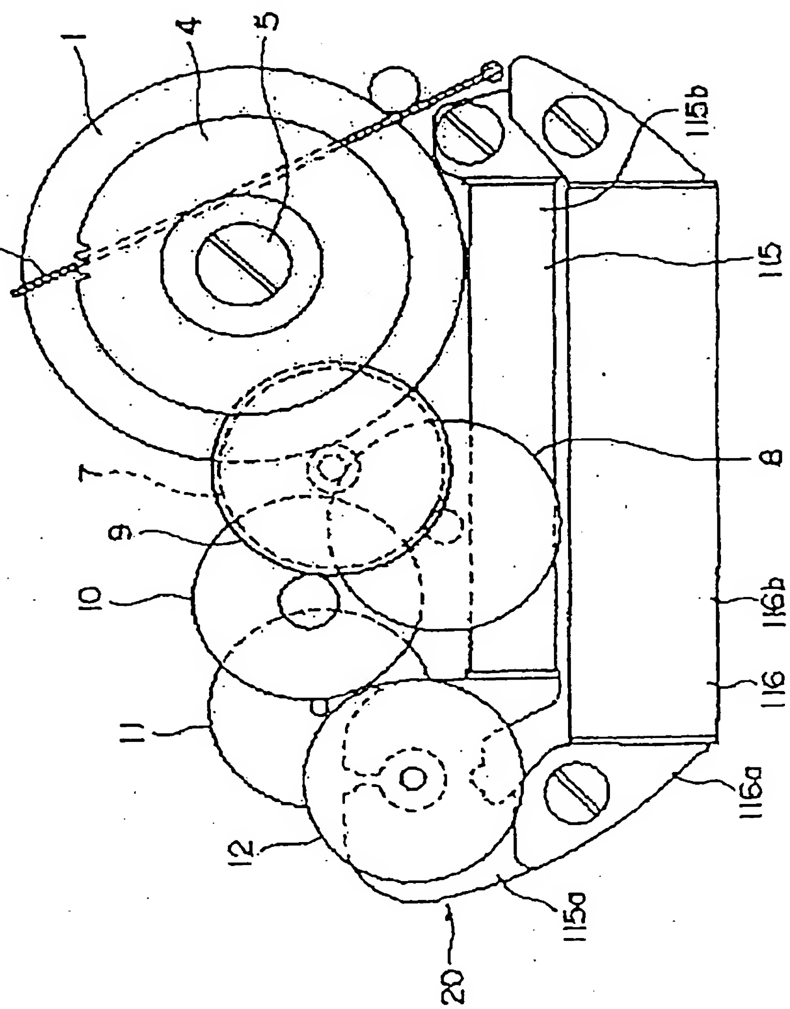
[FIG. 15]


70(+)
92
91
921
911
152
152
152
934
931
94
93
70(−)

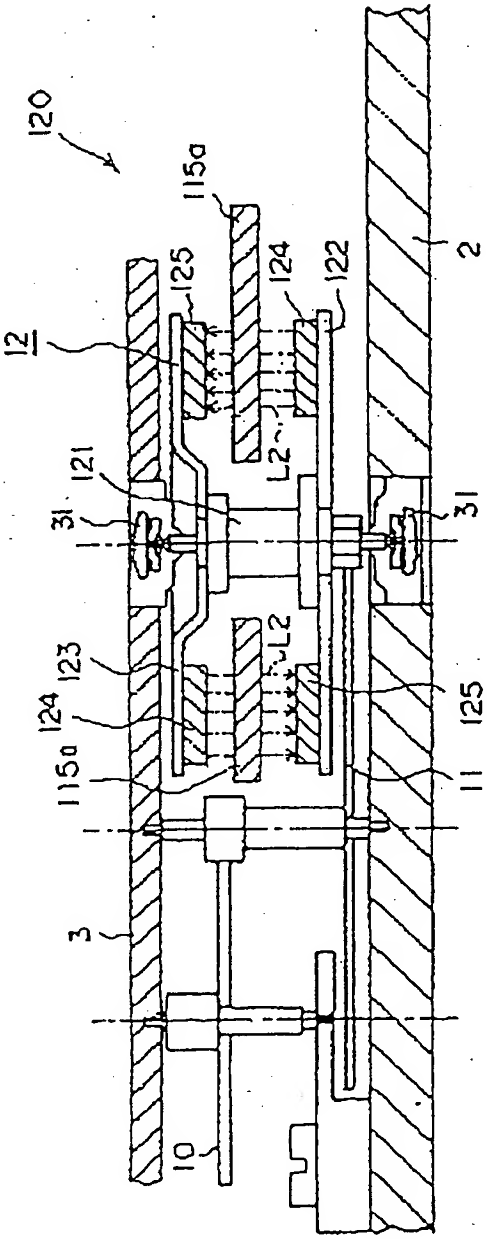
[FIG. 16]


L11
422
624
622
L10
622a
L10

[FIG. 17]



[FIG. 18]



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 7756

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	FR 2 076 493 A (VALROGER PIERRE DE;LAVET MARIUS) 15 October 1971 (1971-10-15) * figures 1-20 *	1-3,5-17	G04C13/11 H02K1/27
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Place of search	Date of completion of the search	Examiner
THE HAGUE	29 December 1999	Exelmans, U

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